Sapphire/Slammer

The Fastest Worm Yet

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Impact of Sapphire

- Major ATM network down for most of a day
- 911 service in a major city lost
- Disruption of provincial elections in Canada
- Numerous companies with network out of control for 1-3 days (but many fine)
- Parts of Internet congested for about 12 hours.
- Overall, moderate disruption.
- But worst worm incident to date

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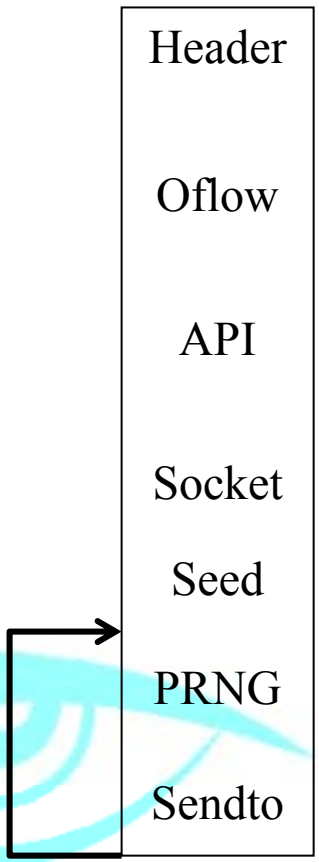
What Was Sapphire?

- Sapphire was a worm in one UDP packet
- 404 bytes total
- Microsoft SQL vulnerability
- Spewed packets at high speed
- Didn't need response
- Spread very fast
  - globally in 10 mins



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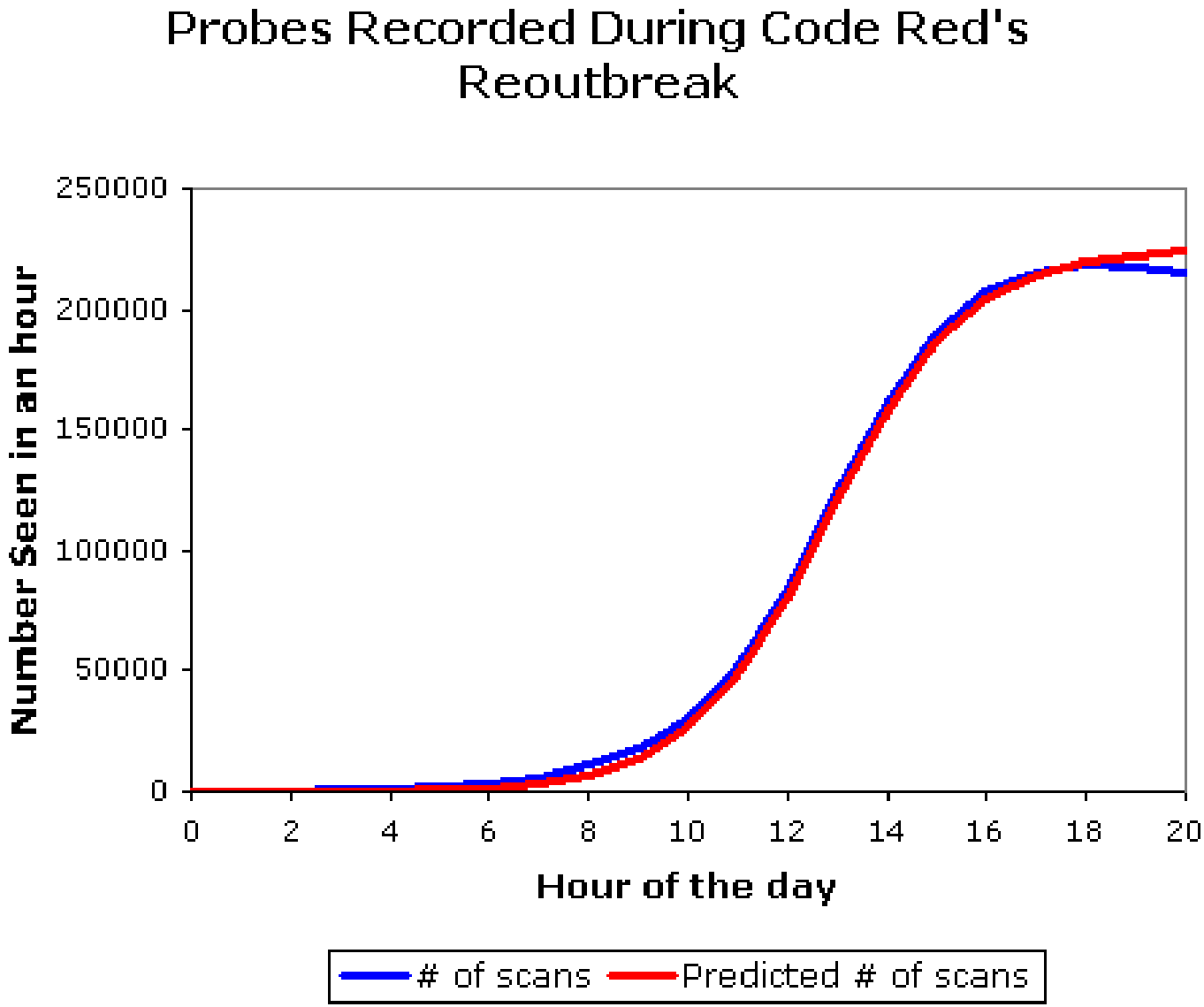
Random Scanning Worms



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Random Scanning Worms II

- Simple scanning worm dynamics
- $a = e^{vS(t-T)} / (1+e^{vS(t-T)})$
- a is proportion infected
- t is time
- Gives sigmoidal graph centered on T
- v is effective vulnerability density (8×10^{-5} for CRI)
- S is effective scan rate (6.25/s for CRI)

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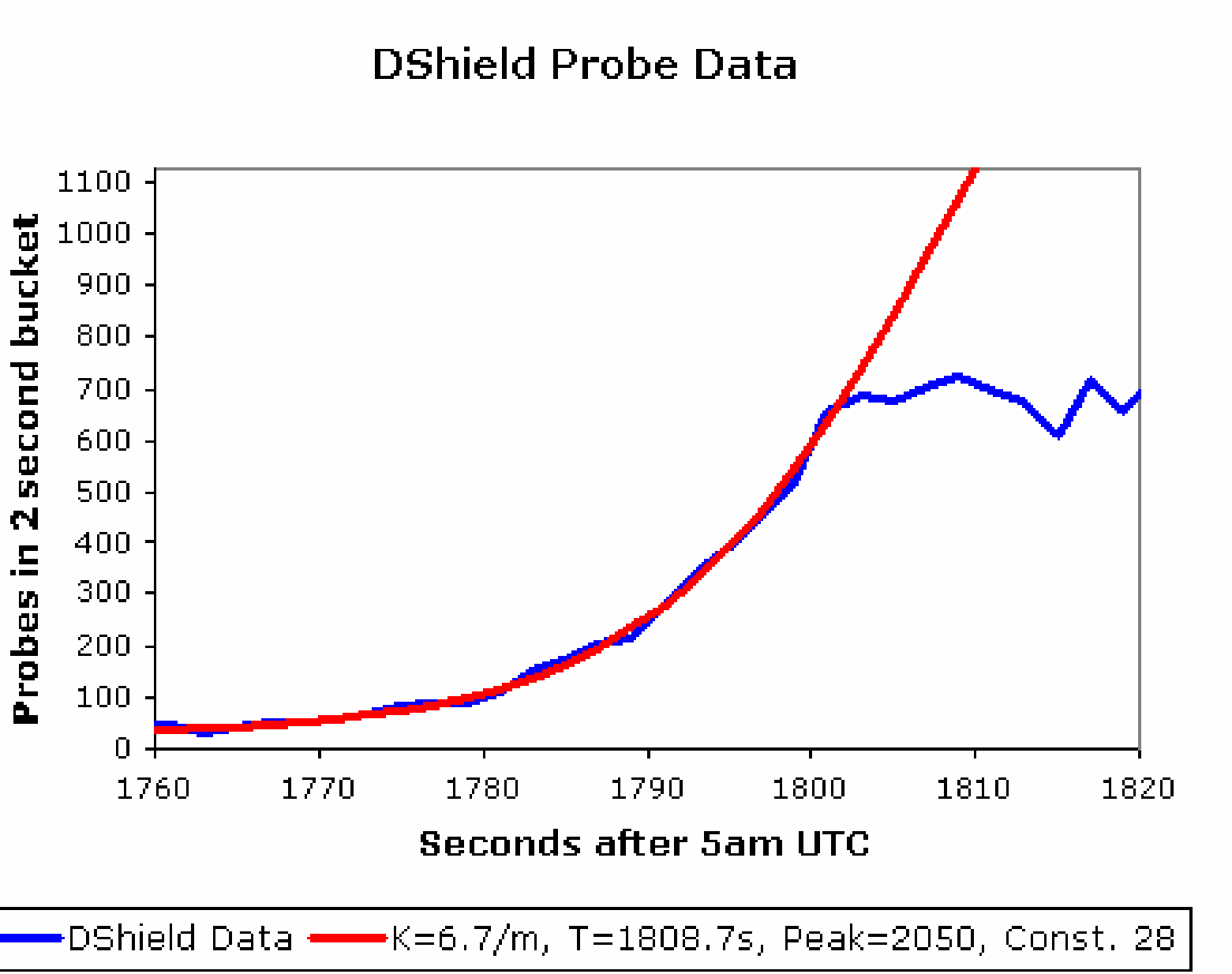
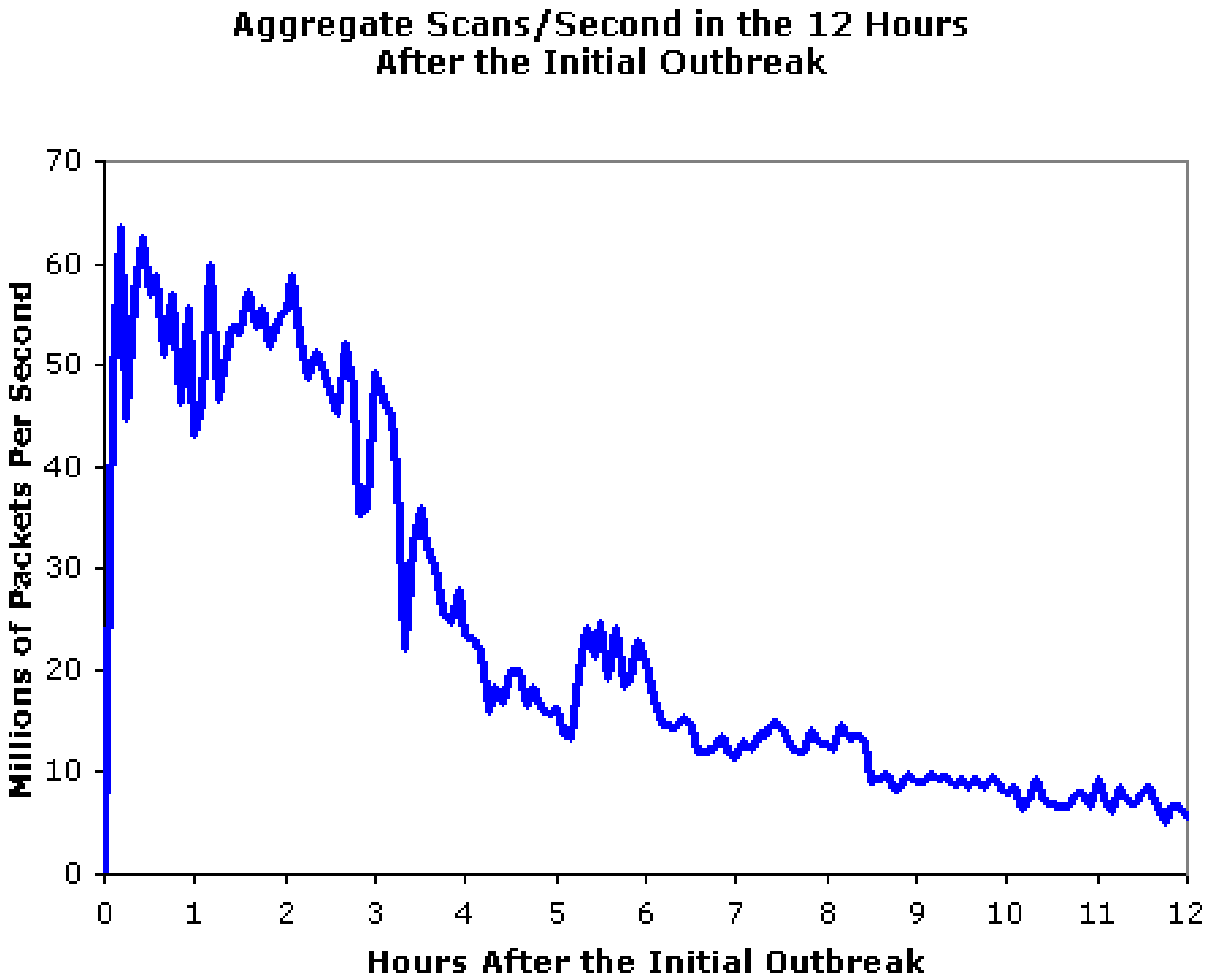
Sapphire Spread Speed



Scan Rates and Response



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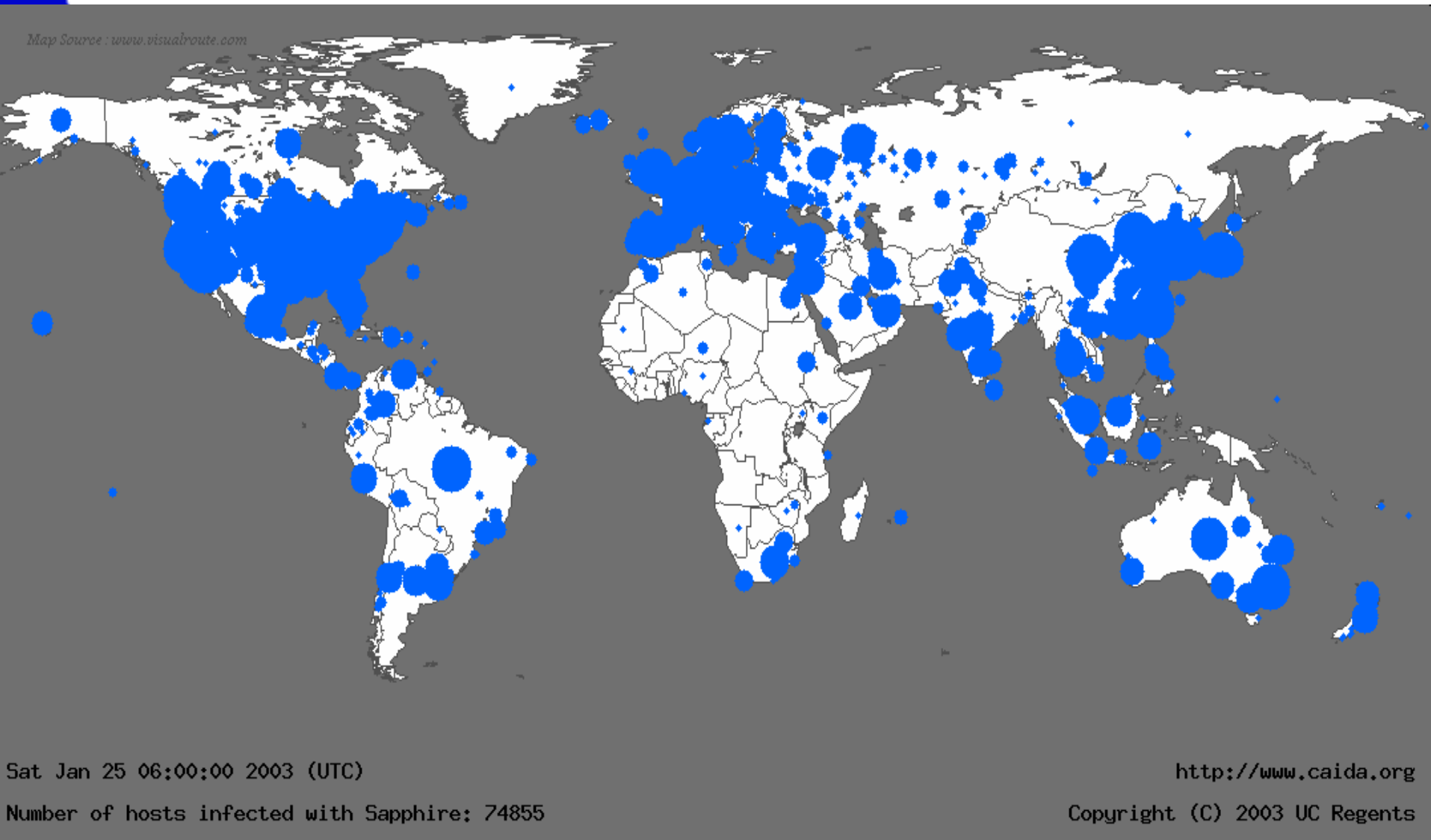
Geographical Spread



Geographical Spread II

Country	% Victims	TLD	% Victims
United States	42.87	UNKNOWN	59.49
South Korea	11.82	net	14.37
UNKNOWN	6.96	com	10.75
China	6.29	edu	2.79
Taiwan	3.98	tw	1.29
Canada	2.88	au	0.71
Australia	2.38	ca	0.71
United Kingdom	2.02	jp	0.65
Japan	1.72	br	0.57
Netherlands	1.53	uk	0.57

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Random Number Generator

- Has defects due to coding errors
- Has cycle structure
  - Each worm copy will stay within initial cycle
  - Cycles amongst certain /16 addresses - doesn't visit all.
  - Several different cycle structures depending on exact version of SQL server
- Therefore hard to count how many Ips infected
- >75000

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Conclusions

- Sapphire was fastest worm ever
- Speed prediction (How to 0wn..): accurate
- Worms can spread in minutes (even RS)
- RS worms can live on smaller vulnerable populations than we realized
  - <20000 on the Internet would be ample to support sub-hour spread
- Can work on TCP (but harder to implement)

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Conclusions II

- Surprising level of disruption for a no-payload, no-firewall-penetrator worm.
- Worm with the above could be devastating
- Need automated defenses

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